jnprsr – A parser for Juniper configuration files

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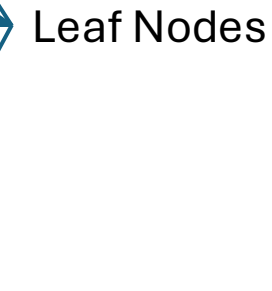
Why? / Motivation

- In 2019 I was building a system for Juniper configuration templates
- I was very annoyed by the fact, that I could not easily compose configuration fragments into a single configuration
- I ended up using the Jinja2 “include“ feature but was not happy about it.
  - Indentation was messed up
  - I need to pay attention that I place the include at the right position
- I thought that there should be an easier way to merge Juniper configuration off-box.

➢ **A new weekend coding project was born!**

What does Juniper Configuration look like?

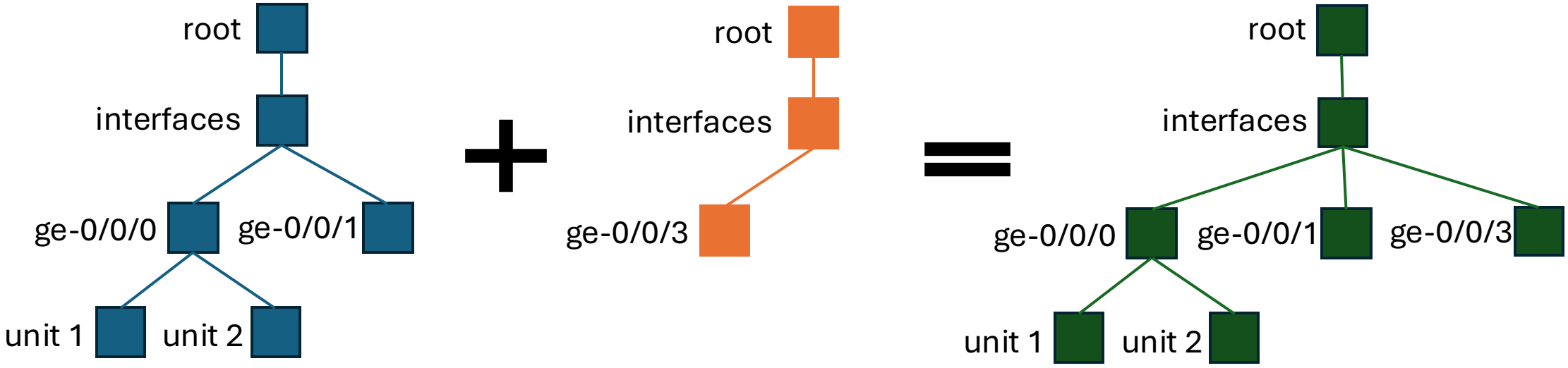
```
system {
    host-name ABC;
    domain-search [ google.com ];
}
interfaces {
    ge-0/0/0 {
        description "blah";
        unit 0 {
            family inet {
                address 1.2.3.5/24;
            }
        }
    }
    ge-0/0/1 {
        unit 0 {
            family inet {
                address 2.2.3.4/24;
            }
        }
    }
}
```



- Juniper configuration uses a hierarchical tree-like data structure.
- Different levels are expressed using curly-braces
- Consists of Container Nodes and Leaf Nodes
- Very similar to concepts found in programming languages like C, C++, Java

How do I approach this?

- Pretty soon, I realized that this was not going to be trivial.
- I would need to generate some kind of tree data structure from the configuration to be able to merge two configurations:



Wait a minute..

- Tree data structures..
- Curly-braces..
- Feels a bit like C, C++ or Java…

➢ **That sounds like a job for a parser!**

➢ **Juniper Configuration can be defined as a formal language!**

What is a formal language?

Consists of

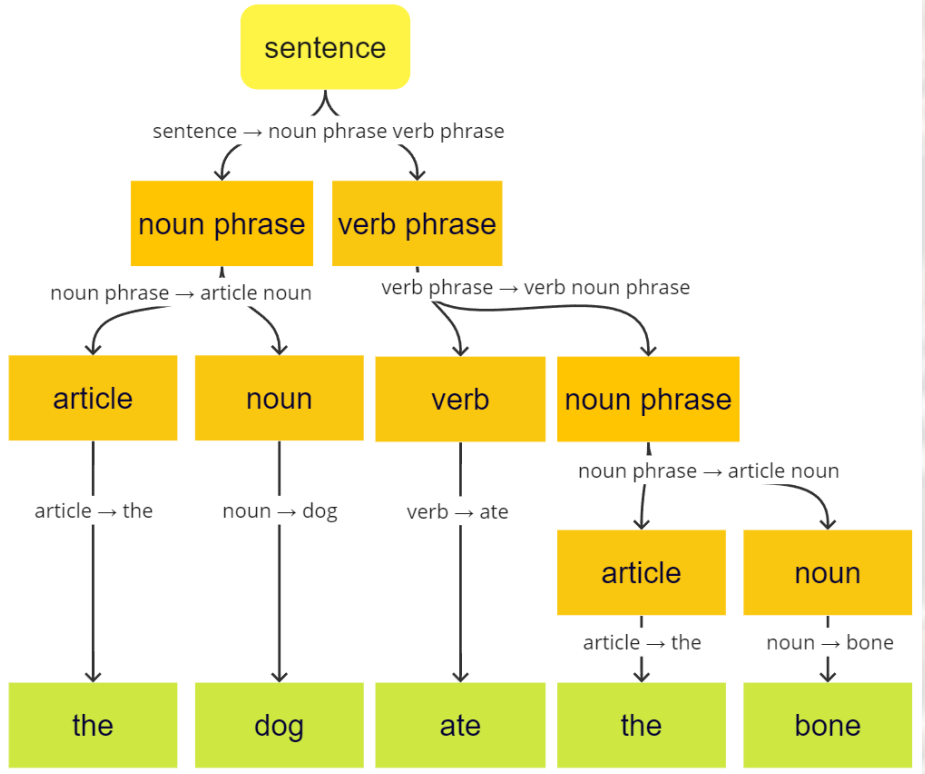
- **Alphabet** as a set of symbols
  {e, o, h, t, b, n, d, g, a}
- **Words** are strings whose letters/symbols are taken from an **Alphabet** according to a set of rules
- **Formal Grammar** is a set of (production) rules describing the syntax of the formal language

Non-Terminal Symbols = {sentence, noun, verb, article, noun phrase, verb phrase}

Terminal Symbols = {dog, bone, the, ate}

Production Rules = {sentence → noun phrase verb phrase,
noun phrase → article noun,
verb phrase → verb noun phrase,
noun → dog or bone,
verb → ate,
article → the}

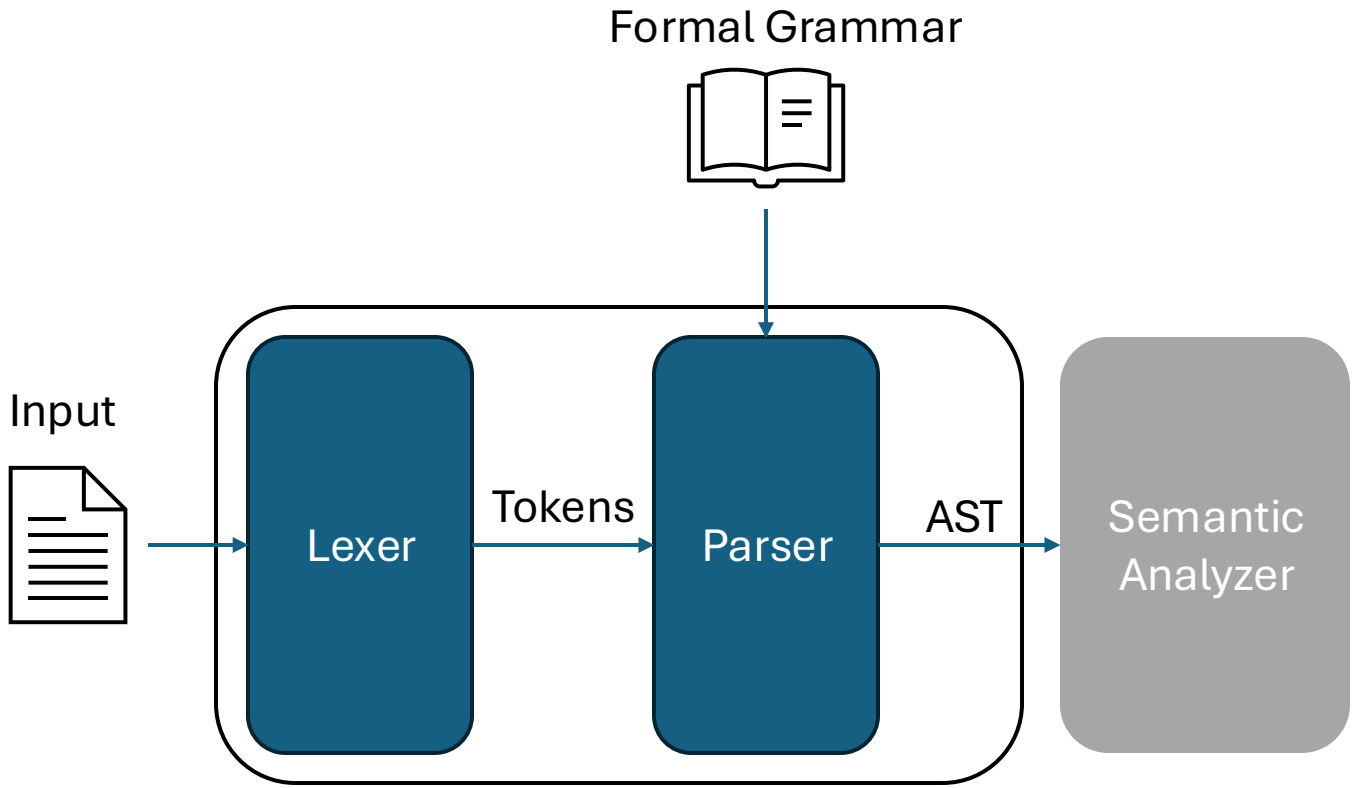
Start Symbol = sentence



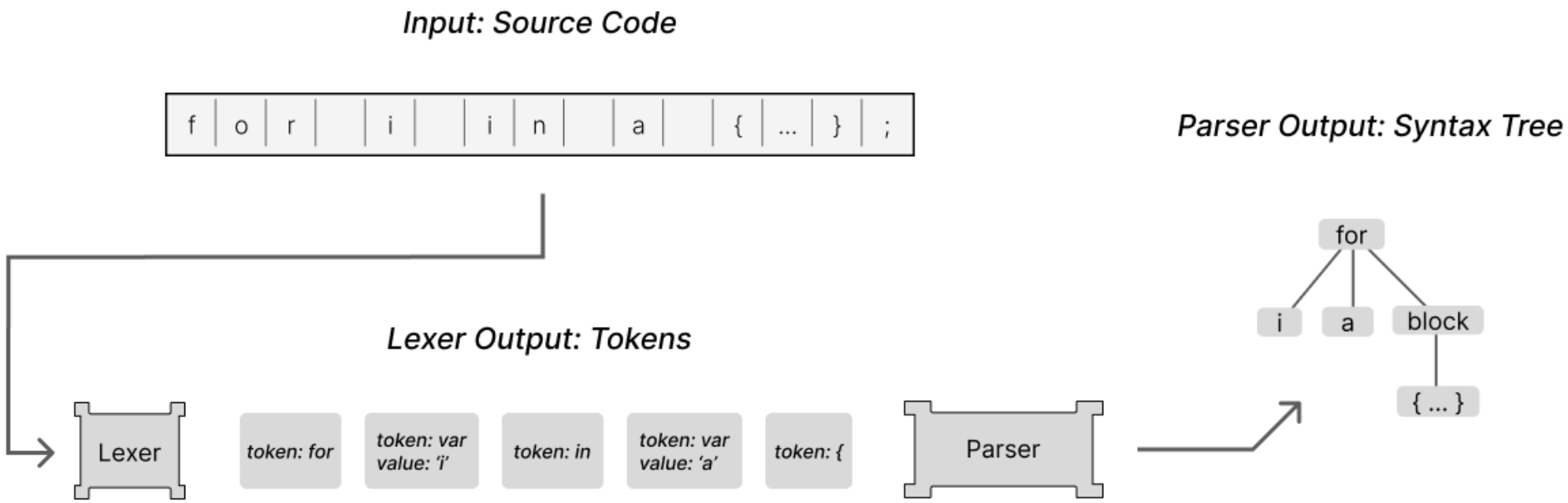
* I am not a theoretical computer scientist and have just shamelessly taken this from Wikipedia :)
Source: https://en.wikipedia.org/wiki/Formal_grammar

What is a parser?

- A parser is a piece of software that analyzes a given series of symbols and produces an Abstract Syntax Tree (AST)
- It is usually combined with a **Lexer** that converts a series of input characters into **tokens**.
- This **stream of tokens** is then read by the **parser** according to production rules defined by a **formal grammar**
- The **parser** then produces an **Abstract Syntax Tree**, which is then usually fed into a semantic analyzer



Parser Example



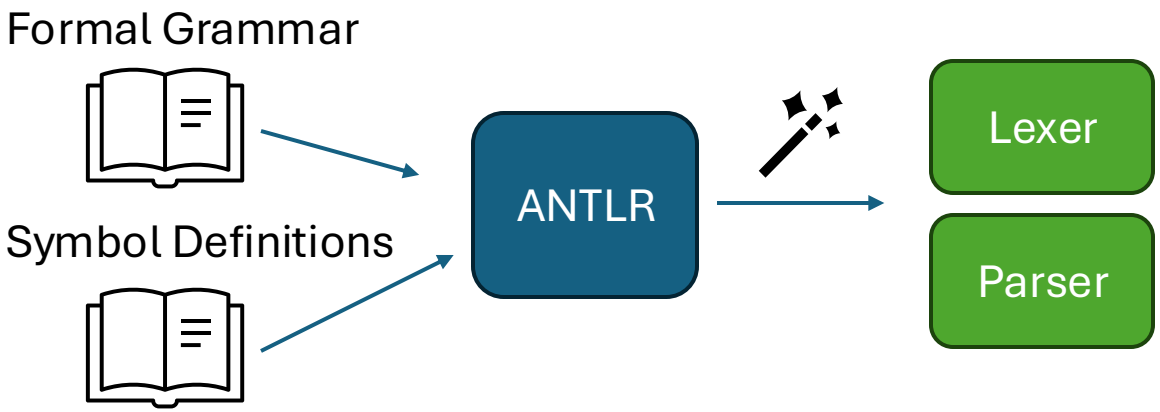
Source: https://www.beau-carlborg.com/blog/parsers-and-encoders-everywhere

Let‘s build a Juniper Config Parser!

- What do we need?
  - A definition of symbols
  - A formal grammar
  - A Lexer based on the symbol definitions
  - A Parser based on the formal grammar
  - Some brains to implement this!

There should be an easier way!

- **And there is**: ANTLR (**AN**other **T**ool for **L**anguage **R**ecognition) is a Parser Generator
- You supply **ANTLR** with the **formal grammar** and **symbol definitions** and it will generate an implementation of the Lexer and Parser in a programming language of your choice:
  - C++, C#, Dart, Java, JavaScript, PHP, Python3, Swift, TypeScript, Go



Let‘s build the parser

- I have based my work on existing ANTLR defintions created by the **batfish** project.
- Luckily I could almost use this as is and had a pretty solid basis for the parser.

Parser

```
parser grammar JuniperParser;

options {
  tokenVocab = JuniperLexer;
}

braced_clause
:
  OPEN_BRACE statement* CLOSE_BRACE
;

bracketed_clause
:
  OPEN_BRACKET word+ CLOSE_BRACKET
;

juniper_configuration
:
  statement+ EOF
;

statement
:
  (
    INACTIVE
    | REPLACE
  )? words += word+
  (
    braced_clause
    |
    (
      bracketed_clause terminator
    )
    | terminator
  )
;

terminator
:
  SEMICOLON
;

word
:
  WORD
;
```

Lexer

```
lexer grammar JuniperLexer;

options {
}

[…]

OPEN_BRACE
:
   '{'
;

OPEN_BRACKET
:
   '['
;

OPEN_PAREN
:
   '('
;

SEMICOLON
:
   ';'
;

WORD
:
   F_QuotedString
   | F_ParenString
   | F_WordChar+
;


[…]
```

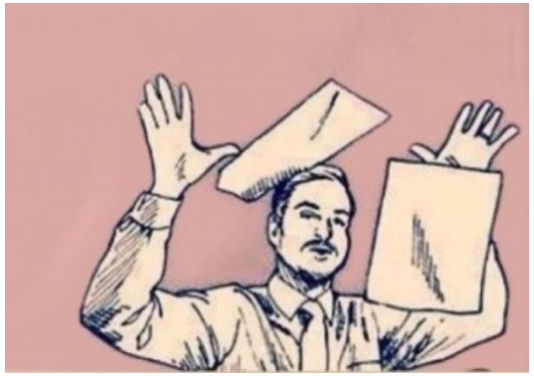
**shortened*

What‘s next?

- Now, I am able to generate an AST from a given Juniper configuration.
- First tests had shown that this worked pretty reliably!

➢ However, the AST tree data type produced by ANTLR is not really suitable for further use

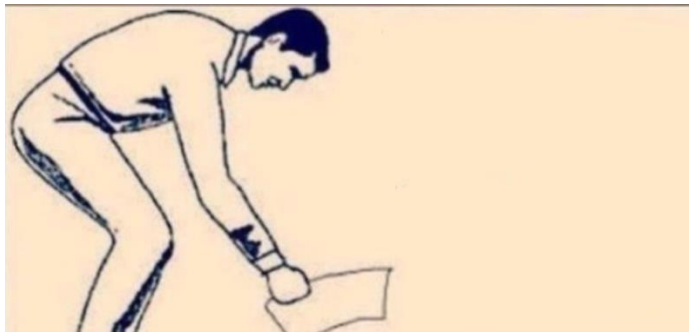
- ➢ No native way to make modifications to it, besides monkey patching
- ➢ No good helper functions to deal with the tree data structure (tree traversal, modification, etc)
- ➢ Not suitable for my goal of merging two configs! :(
- ➢ Project was tossed in the corner for a while.



Homer image source: https://www.deviantart.com/captainedwardteague/art/Home-Simpson-Woo-Hoo-837471740

How do we solve this?

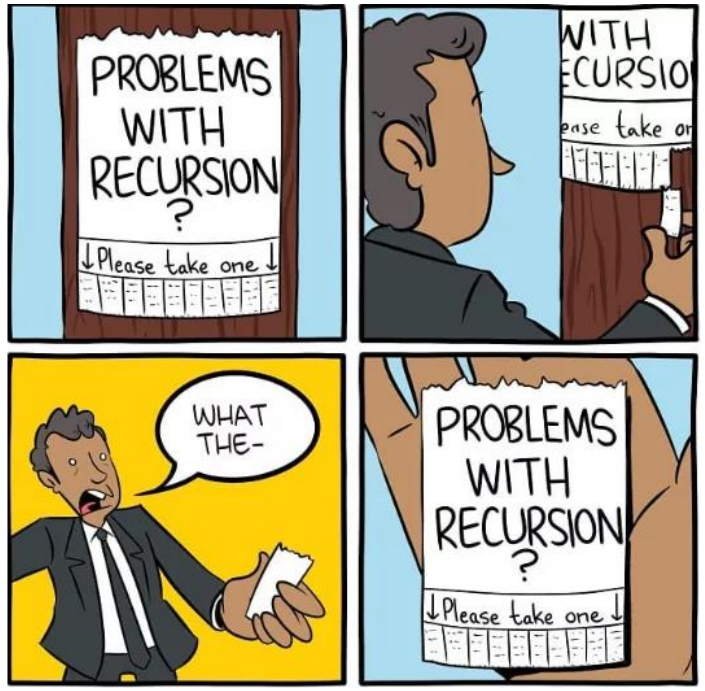
- ANTLR offers something called **ParseTreeListener** and **ParseTreeWalker**
- A **ParseTreeListener** defines various methods that are called when a specific part of the configuration is visited. For components, when a “statement“ is seen.
- A **ParseTreeWalker** allows to traverse a given AST and connect a **ParseTreeLisetner**.
- Using these components, I was able to easily convert the tree into another data format!
- I have chosen the **anytree library**, as it offers many helper functions around the tree data structure

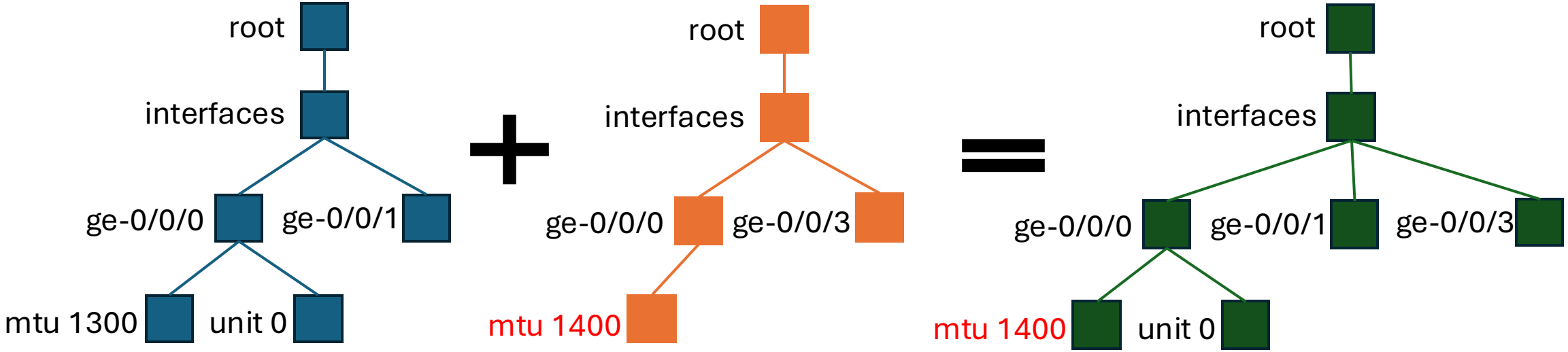


```python
class JuniperAST(JuniperParserListener):
    """
    This Class inherits from the JuniperParserListener created by ANTLR4.
    We are hooking onto various methods called during tree traversal to print out the
config.
    A buffer used inside the class collects the configuration tree reconstructed from
the the tree.
    """
    def __init__(self):
        self.root = JuniperASTNode("root")
        self.point = self.root
        self.depth = 0
        self.in_bracketed_clause = False

    def enterStatement(self, ctx: JuniperParser.StatementContext):
        node = JuniperASTNode(name="", parent=self.point)
        self.point = node
        # Exit a parse tree produced by JuniperParser#statement.

    def exitTerminator(self, ctx: JuniperParser.TerminatorContext):
        self.point = self.point.parent
        # Enter a parse tree produced by JuniperParser#word.

    def enterWord(self, ctx: JuniperParser.WordContext):
        if self.in_bracketed_clause:
            node = JuniperASTNode(name="", parent=self.point)
            self.point = node

        if len(self.point.name) < 1:
            self.point.name += ctx.getText()
            self.point.key = ctx.getText()
        else:
            self.point.name += " " + ctx.getText()
            self.point.value += " " + ctx.getText()

        if self.in_bracketed_clause:
            self.point = self.point.parent
        # Exit a parse tree produced by JuniperParser#word.

    def exitWord(self, ctx: JuniperParser.WordContext):
        pass
```

How are two trees merged?

- We need to define the target and source configuration.
  - In case a leaf node is overwritten by the merge operation, the value from the source will always overwrite the value of the target.
- What do we need to do to merge two trees?
  - We need to traverse through both tress at the same time and find common nodes and different nodes at each level.
    - In case a common node is found and it is a container node, we need to descend.
    - In case different nodes are found, they need to be added to the target tree.
- We need to apply this logic to every level of both trees: **RECURSION**





Target Configuration **Source Configuration** **Merged Configuration**

Let‘s merge then!

- Unfortunately, there are exceptions for configuration merging! :)
- Example 1

```
protocols {
    isis {
        interface lo0.0;
        interface ge-0/1/3.10;
    }
}
```

Target Configuration

+

```
protocols {
    isis {
        interface ge-0/1/4.10;
    }
}
```

Source Configuration

=

```
protocols {
    isis {
        interface lo0.0;
        interface ge-0/1/3.10;
        interface ge-0/1/4.10;
    }
}
```

In this case we have a leaf node with additional parameters. In this instance the interface leaf node will not be replaced, but added to the isis context.

Let‘s merge then!

- Unfortunately, there are exceptions for configuration merging! :)
- Example 2

```
system {
    host-name "blah";
}
```

+

```
system {
    host-name "abc";
}
```

Target Configuration

=

```
system {
    host-name "abc";
}
```

Source Configuration

In this case we also have a leaf node with additional parameters. In this instance however the leaf node will be replaced and not added as an additional node to the system context!

End of the story

- Merging is now implemented, and I have tried to capture all exceptions in the process.
  - Currently trying to cover as many as possible with test cases
- Software now delivers merge operations that are sufficient for my initial use case.

➢ **jnprsr was published**

What can you do with jnprsr?

- Can be used either directly **on your shell** or as **part of your own python script**
- On the Shell we currently support
  - Pretty-Printing
  - Sub-Tree Selection / Interactive CLI
  - Merge

On your shell: What can you do with jnprsr?

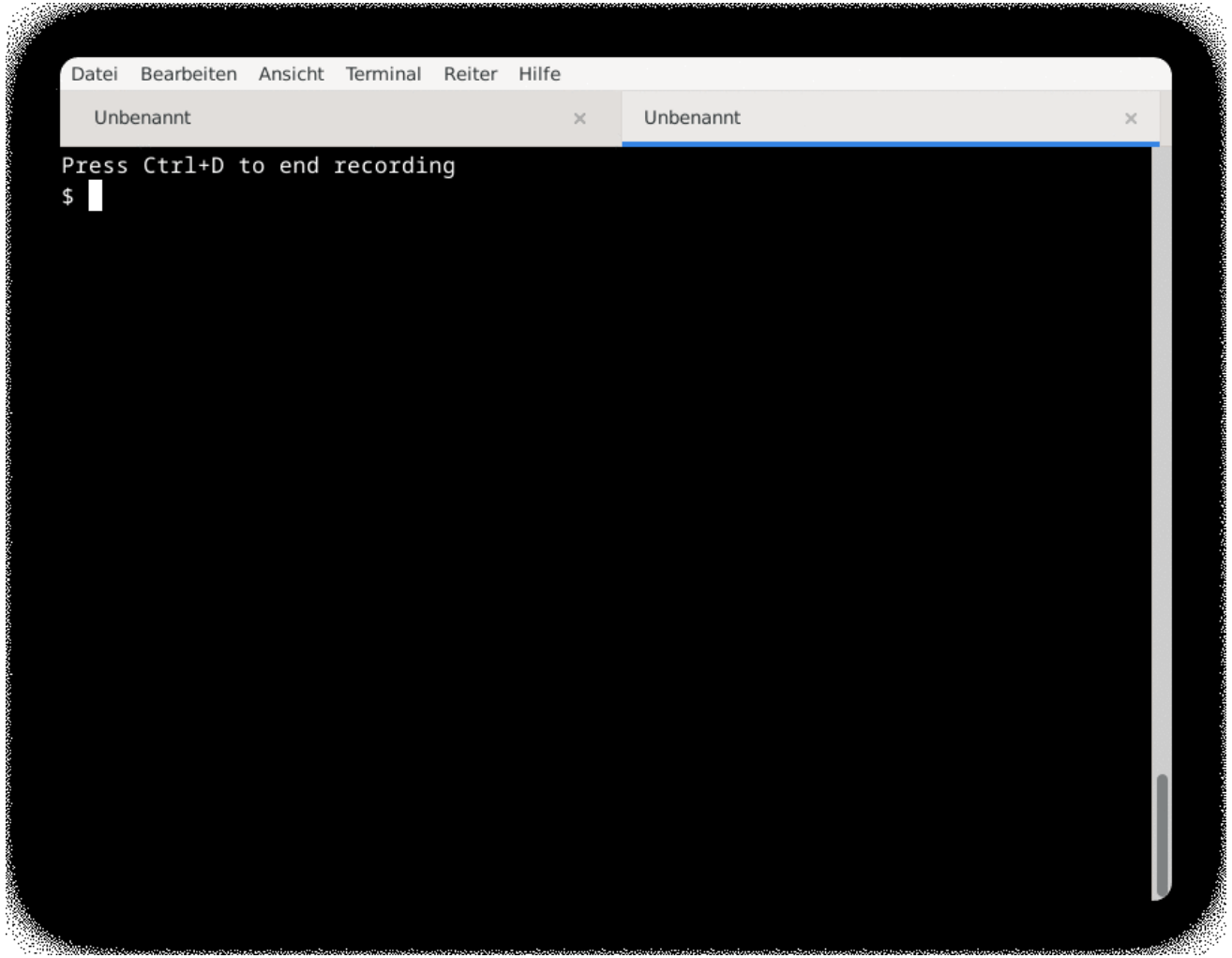
- Pretty-Printing

```
$ jnprsr-pretty
[Type CTRL+D or '!END' at a new line to end input]
interfaces { et-0/0/0 {description "More Bandwidth!"; unit 0 {family inet{address
192.0.2.1/24;}}}}
interfaces {
    et-0/0/0 {
        description "More Bandwidth!";
        unit 0 {
            family inet {
                address 192.0.2.1/24;
            }
        }
    }
}
```

```
$ cat what-a-mess.txt | jnprsr-pretty -s
interfaces {
    et-0/0/0 {
        description "More Bandwidth!";
        unit 0 {
            family inet {
                address 192.0.2.1/24;
            }
        }
    }
}
```

On your shell: What can you do with jnprsr?

- Sub-Tree Selection / Interactive CLI



On your shell: What can you do with jnprsr?

- Merge

```
$ cat test1.txt
system {
    host-name "test";
}
$ cat test2.txt
system {
    name-server {
        10.4.3.222;
    }
}
$ jnprsr-merge test1.txt test2.txt
system {
    host-name "test";
    name-server {
        10.4.3.222;
    }
}
```

In your script: What can you do with jnprsr?

```
import jnprsr

config = "system { host-name "test"; }"
ast = jnprsr.get_ast(config)
```

- You will almost always start with the **get_ast()** function. It will parse a given string and return an object of the type **JuniperASTNode**.
- This datatype inherits properties from the **anytree NodeMixin** type. So, you can work with this object the same way you would work with an anytree tree.

For ease of use we have created some Juniper Configuration specific helper functions:

- **render_config_from_ast(ast: JuniperASTNode) -> str**
  - This will return a textual representation of the AST, meaning it will converted back into configuration text.
- **render_ascii_tree_from_ast(ast: JuniperASTNode) -> str**
  - This will return an ascii tree representing the AST, because why not? :)
- **render_dict_from_ast(ast: JuniperASTNode) -> dict**
  - This will return a dictionary from a given configuration file.
- **merge(ast1: JuniperASTNode, ast2: JuniperASTNode) -> JuniperASTNode**
  - This will merge ast2 onto ast1
- **get_sub_tree(ast: JuniperASTNode, path: str) -> JuniperASTNode**
  - This will return the subtree at specified path, for example 'interfaces et-0/0/0'

What you can build with jnprsr

- Config Template Management Systems
- Configuration Validation
  - Is something correctly configured?
  - Are best-practices used?
- Comparing Configurations
  - Building a diff should be fairly easy
- Renderer that will output config in „set“ format
- Configuration Converter
  - Convert an existing Juniper config to the configuration of another vendor
  - Probably quite complex

Where can I get jnprsr?

- Code is available on GitHub
  - https://github.com/markusju/jnprsr
- You can install **jnprsr** using pip:

```
$ pip install jnprsr
```

- Do you want to work on this?
  See something I messed up?
  Want to add a new feature?

➢**Send me a pull request!**

Thank you!